

# **Effects of Circuit Training for Adolescents and Young Adults with Spastic Diplegia**

Alison Cargeeg<sup>2</sup>, A.M. Blackmore<sup>1 2</sup>, PhD, and Scott Phillips<sup>3</sup>, BSc (Physiotherapy)

<sup>1</sup>Curtin University of Technology.

<sup>2</sup>The Centre for Cerebral Palsy

<sup>3</sup>Disability Services Commission

## **ACKNOWLEDGEMENTS**

We gratefully acknowledge the co-operation of the participants in this study and their families; and the assistance of Jon Ansell, Janine Spiby, Dayna Pool and Jin Ou, and the adolescent and adult teams at The Centre for Cerebral Palsy (TCCP); as well as, Dr Diana Hopper and Peter McKinnon from Curtin University of Technology. This study was conducted using the facilities at TCCP.

---

Address correspondence to first author at:

Alison Cargeeg, Physiotherapist, The Centre for Cerebral Palsy

PO Box 61, Mount Lawley, 6929, Western Australia, AUSTRALIA

Phone: +61 8 9443 0367, Fax: +61 8 9444 7299, Email: Alison.Cargeeg@tccp.com.au

This study was undertaken by Alison Cargeeg for a Bachelor of Science (Physiotherapy) Honours degree at Curtin University of Technology

## ABSTRACT

**Purpose:** This study was designed to investigate the effects of a circuit-training program for adolescents and young adults with spastic diplegia.

**Methods:** In a one-group pre-test, post-test, follow-up design, nine adolescents and young adults (14 to 22 years) participated in a ten-week program of cardiovascular fitness and strength exercises. Outcome measures reflecting the levels of the Classification of Functioning Disability and Health (ICF), included: for impairment biomechanical analysis and fitness test, for activity 1 minute walk test and Timed Up and Go test and for participation Assessment of Life Habits Questionnaire (LIFE-H). Qualitative interviews were also conducted.

**Results:** There was a significant decrease in popliteal angle bilaterally and self-reported improvements in strength, fitness, self-confidence, gait and physical activity participation.

**Conclusion:** This research demonstrated circuit training can be a viable and enjoyable strategy for adolescents and young adults with cerebral palsy and a safe and effective step towards community-based physical activity.

## INTRODUCTION

Cerebral palsy (CP) describes, “a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to nonprogressive disturbances that occurred in the developing fetal or infant brain”.<sup>1 p.9</sup> The primary impairments in CP are abnormal gross and fine motor function caused by abnormal motor control. These impairments lead to difficulty co-ordinating activities such as walking, feeding and speech, and often disrupt participation.<sup>1</sup>

Although CP results from a static lesion, the manifestations of the disease change as the child grows, as abnormal biomechanical forces, immobility and overuse cause excessive stress on bodily structures and early joint degeneration.<sup>2</sup> This may result in a decline in gross motor function during adolescence and early adulthood.<sup>3</sup> A decline in ambulatory ability may also lead to dependence on walking aids, wheelchairs, handrails and others for assistance.<sup>4</sup> For example, ten-year-old children who walk well but require a handrail for stairs are as likely to experience a decline in function as they are to improve by age 25.<sup>4</sup> Thus the transition from school into the wider community is especially challenging for people with CP.<sup>39</sup> Furthermore adolescents and young adults with CP tend to be poorly integrated socially and have disrupted participation in employment, education, community living and recreation.<sup>40</sup>

Spasticity has long been regarded as a significant impairment causing motor dysfunction in CP.<sup>5</sup> With the improvement in medical techniques to decrease spasticity, decreased muscle strength and abnormal muscular control are now recognized as key impairments impeding function.<sup>6</sup> Muscle weakness is present even in individuals with mild CP.<sup>6</sup> It results from inactivity, as well as from primary and secondary impairments in the muscles and neurological pathways, and may be exacerbated by the neurosurgical and orthopaedic interventions to which this population are often exposed.<sup>7</sup> Until recently

strength training was avoided clinically for people with CP. However, there is no evidence that strength training causes an increase in spasticity.<sup>7, 8</sup>

In May 2001 the World Health Assembly (WHO), endorsed the Classification of Functioning Disability and Health (ICF) for the measurement of health and disability.<sup>9</sup> The ICF recognizes that disability is not a discrete medical entity but that social and environmental features known as *contextual factors* affect the individual's function, a continuum broken into three levels: *body functions and structures*, *activity* and *participation*.<sup>9</sup> Disease or disability may lead to disruption at each level known as an *impairment*, *activity limitation* or *participation restriction* respectively.<sup>9</sup> Since its introduction, researchers in the disability field have increasingly selected their outcome measures to reflect the three ICF levels, thus ensuring that interventions are considered in terms of their ability to bring about meaningful changes in an individuals' functional ability and quality of life.<sup>7</sup>

In 2002, a systematic review was conducted to investigate the effects of strength training for people with CP within the framework of the ICF.<sup>8</sup> Only one Randomised Clinical Trial (RCT) and one review article were included in the 11 articles evaluated. None of the articles reported negative effects of training. At the *impairment* level, improvements were reported in strength, range of motion and, in one study, self-perception. Reported improvements in posture, ambulatory velocity and stability as well as ability to self-propel a wheelchair were found at the *activity* level. No study assessed the effects of strength training on *participation*. The 2002 systematic review concluded that strength training improves muscle action in children and adolescents with CP and that research should examine changes in activity and participation (not merely in bodily function) that result from strength training. Contextual factors, such as program setting and the benefits of individual versus groups programs also needed to be explored.<sup>8</sup>

Over the last six years, these areas have developed. At the *impairment* level two RCTs have reported significant improvements in strength and ROM.<sup>5, 10</sup> Two qualitative studies have reported changes in psychological function including improved self-perception of physical appearance, discipline, energy, self-confidence and sense of well-being.<sup>11, 12</sup> Further, a RCT reported a significant difference between groups in body image after eight weeks of strength training.<sup>13</sup>

At the *activity* level, strength training has led to improvements in ambulatory ability, including increased walking velocity,<sup>5, 14</sup> decreased energy expenditure during ambulation,<sup>14</sup> and a more upright posture during stance phase<sup>13</sup> in adolescents and adults. Significant improvements in times for the Timed Up and Go test (TUG) and timed sit-to-stand have also been found.<sup>5, 15</sup> A recent RCT also reported improvement in functional competence in a self-perception questionnaire for climbing stairs unsupported and walking between classrooms.<sup>13</sup> Qualitative studies have reported improved walking, running, jumping, squatting, getting up off the floor, stepping up, sit to stand and transferring, dressing and showering.<sup>11, 12</sup>

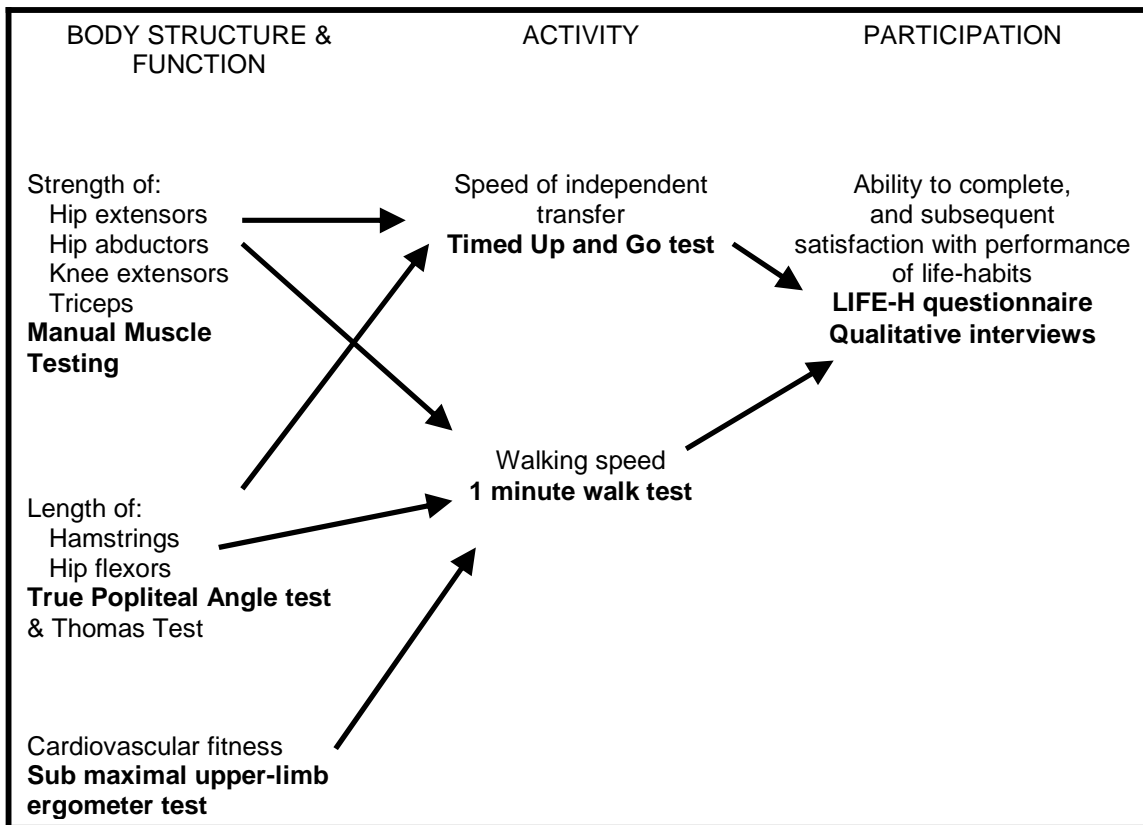
There is qualitative evidence that strength training increases participation in school, leisure, social and family activities<sup>11</sup> but the effect of strength training on the *participation* levels of people with CP remains largely unknown. Although adolescents and young adults often show reduced function and participation, no study assessing strength training has spanned this age range.

The extent to which strength training affects participation may be dependent on *contextual factors*. A group program in a community setting may increase societal participation more than an individual or home-based program.<sup>16</sup> A number of studies have conducted group-based strength training in community settings.<sup>5, 12, 15, 17</sup> Authors of one such study concluded that teenagers with CP should be capable of using a community weight-training facility with only minimal assistance.<sup>17</sup> Enjoyment, primarily from social interaction, has been reported as a key benefit of group-based community training.<sup>12</sup>

There is little research on fitness training, as distinct from strength training, for people with CP.<sup>7</sup> Adolescents with spastic diplegic CP have poorer levels of cardiovascular fitness than the unaffected population<sup>18</sup> and poor physical fitness leading to impaired health and function is a major problem for children with CP.<sup>19</sup> Training produces improvements in cardiovascular fitness, physical endurance and peak aerobic power.<sup>20-22</sup> Case study reports have also found improved strength, gross motor function, gait efficiency, and self-perceived appearance following aerobic training.<sup>23</sup> Further research is needed to assess the benefits of fitness training on functional mobility and quality of life.<sup>24</sup>

Circuit training is a generalised conditioning program that increases muscular strength and endurance and improves cardiovascular fitness in the general population.<sup>25</sup> It combines low-resistance, high-repetition exercises aimed at improving muscular endurance with exercises that increase flexibility and cardiovascular fitness. Although circuit training is popular among adolescents and young adults without disabilities, and is offered in many community gymnasiums, its potential benefits for general health and community participation in people with CP have never been assessed

The purpose of this study was to determine whether a ten-week circuit-training program could lead to measurable changes in *impairment*, *activity*, and *participation* in adolescents and young adults with spastic diplegia. To assess participants' *impairment* level, cardiovascular fitness and strength of the hip extensors, hip abductors, knee extensors and the triceps were measured, as were length of the hip flexors and hamstrings. *Activity limitation* was assessed by speed of transfer and walking velocity. *Participation* was assessed by measuring participants' ability to perform, and their satisfaction with their performance of, life habits. (Life habits include regular actions and social roles.<sup>26</sup>) Qualitative interviews were conducted to investigate the benefits and difficulties of training at all three levels. Figure 1 shows the relationships among these variables. The study also explored the feasibility of a program to teach adolescents and young adults how to independently use training equipment found in the community.



**Figure 1:** A schematic representation of the measured variables and outcome measures (bolded) used in this study, and in relation to the levels of the ICF.

## METHODS

### Study Design

A one-group pre-test, post-test, follow-up design was used.

### Participants

Nine participants (three male and six female) were recruited from The Centre for Cerebral Palsy (TCCP) client group. Inclusion criteria were 1) diagnosis of spastic diplegic cerebral palsy, 2) aged 13 to 35 years, 3) ability to ambulate with or without aids for one minute, and 4) ability to follow instructions and answer simple questions. Exclusion criteria were 1) current participation in a gymnasium training program, 2) orthopedic management in previous six months and 3) taking medication affecting heart rate.

Eligible clients of TCCP received a letter, an information sheet, and a follow-up phone call from TCCP staff, usually their own therapist. Before commencing, participants (and their parents, if they were under 18 years) gave written informed consent and were screened for contra-indications to exercise. No participant was excluded at this stage.

During pre-testing participant 6 showed an abnormal cardiovascular response to exercise, indicating exercise testing should be discontinued.<sup>27</sup> Assessment was terminated and the participant was sent to her General Practitioner with a letter detailing the researchers' concerns. The General Practitioner approved her continuation in the study. However, during training sessions, the participant's physiotherapist raised further concerns. Participant 6 was withdrawn from the study after five training sessions while awaiting further investigation. All other participants attended at least 75% of the training sessions, as indicated in Table 1.

**Table 1:** Participant demographics

Participant	Age	Sex	Number of Sessions	Aids used
1	14	F	19	None
2	14	M	19	None
3	19	F	17	None
4	21	F	18	Fixed AFOs
5	15	F	15	None
6	15	F	5	Fixed AFOs
7	19	M	18	Fixed AFOs and quadstick
8	18	F	18	None
9	17	M	19	Fixed AFOs

AFOs, Ankle Foot Orthoses

### Instruments and Tests

Two assessors, each of whom always conducted the same tests, tested participants at pre-test, post-test and 6-week follow-up. Medications and the use of orthotics or assistive devices were recorded. As this study was intended as a clinically based evaluation, instruments and tests used were generally common clinical measures and all used equipment accessible at TCCP. Participants were tested in the following order: activity measures, biomechanical analysis, cardiovascular fitness test, questionnaire and interview. Before the testing, participants had five minutes rest while seated.

### Impairment Measures

**Biomechanical Analysis** was conducted in the following order: Thomas Test, True Popliteal Angle Test, followed by manual muscle testing (MMT) of elbow extensors, hip abductors, hip extensors and knee extensors. The first author used the conventional clinical methodology for these tests,<sup>28, 29</sup> with an assistant to hold the limbs. A standard universal goniometer was used for the Thomas and True Popliteal angle tests. Intra-tester reliability of goniometric measures in children with spastic diplegia has been found to be high (ICC values ranging from 0.6 to 0.99).<sup>30</sup> These angles were measured three times and the mean, to the nearest degree, was calculated. The ability to perform Activities of Daily Living

(ADLs) has been found to be significantly influenced by strength as determined by MMT grades ( $p < 0.0001$ ) in adults with CP.<sup>31</sup> Two repetitions were performed to allocate MMT grades<sup>29</sup> to each muscle group. Both grades were recorded and the second result was used. MMT grades were converted to a 10-point ordinal scale for data analysis.

**The Sub-maximal Upper Limb Ergometer Test.** Previous studies have used upper limb ergometer tests to measure fitness in children with spastic CP following aerobic training.<sup>21,22</sup> Participants wore polar monitors and, after a two-minute warm-up, a resistance was selected on the ergometer to elicit a heart rate that was 55% of the participants' age-predicted heart rate max (calculated as 220 minus the participants age in years minus 13). Participants pedalled at this resistance, at 60 rotations per minute, for three to six minutes until the heart rate was within three beats at two consecutive minute-intervals. An average of these two heart rates was used to indicate the heart rate at that resistance. The participant then completed a one-minute rest, pedalling at a self-selected speed against no resistance. The same process was repeated with targets of 65% and 75% of the participants' age-predicted heart rate maximum. The resistance and heart rate responses were then graphed. Finally, participants completed a two-minute cool down and were monitored as their heart rates dropped.

### Activity Measures

**1 minute walk test.** A strong association was found between distance walked in one minute and gross motor function, as measured by the Gross Motor Function Measure (GMFM), in a group of 34 children and adolescents with CP.<sup>32</sup> A significant, moderate correlation has also been found between 1 minute walk distance and measurement of oxygen consumption in adolescents with spastic CP (adjusted  $r^2 = 0.477$ ,  $P < 0.001$ ).<sup>33</sup> As in the aforementioned study assessing the tool's validity,<sup>32</sup> participants walked around a 20-meter marked course as quickly as they could for one minute without running. Participants began the test two meters behind the start point and the stopwatch was started as they passed the first cone. The assessor measured the distance covered by the participants using a meter circle.

**Timed Up and Go test** has been used successfully to detect change following strength training in adults with CP.<sup>5</sup> The participants began seated in a standardised chair, leaning against the back of the chair, (with their arms on the armrests and assistive devices in hand if necessary) three meters behind a 30 cm line on the floor. After demonstrating the task, the assessor recorded the time it took the participant to stand, walk around the line without touching it and return to sitting on the chair, to the nearest second. Participants completed two trials, and the second was used.

### Participation Measures

**Assessment of Life Habits Questionnaire (LIFE-H) short version 3.1** LIFE-H short version 3.0 has been found to have good intra-rater reliability in older adults with physical disabilities (ICC values  $> 0.75$  in seven of ten categories).<sup>34</sup> The LIFE-H for children was recommended as the most appropriate choice for measuring participation of children with CP in a structured review evaluating tools' validity, reliability, and feasibility.<sup>35</sup> The questionnaire was conducted at pre-test and follow-up testing only, because a pilot study found decreased participation at post-test due to participants' commitment to the

training program. Where possible, for participants under 18, or with intellectual disabilities, a parent was present in the interview. The questions asked participants: how *difficult* they found these life habits, how much *assistance* they needed to complete them, and how *satisfied* they were with their performance. Categories included: nutrition, fitness, personal care, communication, housing, mobility, responsibilities, interpersonal relationships and community life. Participants' responses for the first two questions were then converted into a standardised score. For the participants' satisfaction level, there is currently no formula for obtaining a standardised score.<sup>26</sup> In this study, we used the mean satisfaction in each category.

### Qualitative Interviews

Interviews included a series of open-ended questions at post-test and follow-up. See Table 2. Responses from participants and their parents were audiotaped.

**Table 2:** Interview questions

Test Time	Question
<b>Post-test</b>	1. Have you noticed any changes within yourself now that you have finished the program? Any changes that other people have noticed in you?
	2. Was there anything difficult about doing the program?
	3. Would you like to continue doing a regular training program?
	4. Do you have any other feedback about the program?
<b>Follow-up</b>	1. Have you noticed any changes within yourself since you finished the program? Or that other people have noticed in you?
	2. Are you continuing to do any exercise or training now?
	3. Are there any differences in your activity level since before the program?

### Intervention Procedures

Participants attended either of two circuit-training programs at TCCP gymnasium. The programs were identical but ran at different times of the year. Each consisted of ten stations, five aimed at increasing muscular strength and endurance and five at cardiovascular fitness. Participants alternated between the two. The equipment was selected for its suitability for people with CP, but was not adapted, and was the same as would be found in a community gym. The stations included: 1) treadmill, 2) triceps push-down, 3) stepper or elliptical trainer, 4) lat pull-down, 5) stairs, 6) vertical chest press, 7) rowing ergometer 8) supported row 9) stationary bike or reclined bike 10) leg press.

Participants attended the program twice a week for 10 weeks. A student exercise physiologist and a TCCP physiotherapist supervised the circuit. Before and after each session, participants were led in

a warm-up and cool-down for five to ten minutes, which involved walking and stretching the major muscle groups in the upper and lower limbs.

Participants worked at each station for one and a half minutes and transferred to the next station as quickly as possible. In the first week, one circuit was performed each session, participants familiarized themselves with the equipment and appropriate resistance levels were selected. Participants wore polar heart rate monitors at all times and for cardiovascular stations, the level was selected to elicit a heart rate between 65 and 85% of their age-predicted heart rate maximum (calculated as 220 minus their age in years or a maximum of 200 beats per minute). For resistance stations, the level was the maximal weight the participant could work at for a minute and a half. For the next three weeks participants continued to complete one full circuit each training session. In weeks five to ten, participants completed two full circuits each session. In week eight the resistance was increased.

### **Data Analysis**

All participants attended all testing sessions, except for participant 6, who missed the post-test but attended pre-test and follow-up. For the analysis, this participant's pre-test data were imputed at post-test. SPSS Version 14 was used. Alpha was set at 0.05. Friedman's test was conducted on each outcome measure. Where a significant difference was found, Wilcoxon's Signed Rank test was used to compare pre-test with post-test and with follow-up. Wilcoxon's Signed Ranks was also used to compare pre-test with follow-up data from the LIFE-H. Interviews were transcribed, and a thematic analysis was conducted to determine participants' views on the effects of the program on their impairment, activity limitations and levels of participation.

### **RESULTS**

The means and standard deviations for each measured variable at pre, post and follow-up are in Table 3. There was a significant decrease in popliteal angle bilaterally with training; on the left between pre and post-test ( $P= 0.012$ ) and on the right between pre and follow-up ( $P= 0.011$ ). No other significant differences were found. Post hoc power calculations showed that 51 participants would have been needed to obtain a 10% improvement in the 1 minute walk test and 33 in the LIFE-H, with 80% power and alpha of 0.05.

**Table 3:** Outcome measures at Pre-test, Post-test, and Follow-up

Outcome Measure	Pre-test		Post-test		Follow-up		P Value
	Mean	SD	Mean	SD	Mean	SD	
<b>Impairment measures</b>							
Thomas Test (left)	7.22	6.55	9.44	5.5	10.78	2.86	0.206
Thomas Test (right)	8.11	5.21	9	4.5	10.33	4.33	0.227
True Popliteal Angle (left)	57.89	14.21	45.22	12.94	46.56	20.12	0.017
True Popliteal Angle (right)	51.22	14.3	41.89	18.73	34.33	16.5	0.009
Triceps (left)	9.89	0.33	9.78	0.44	9.89	0.33	0.368
Triceps (right)	10	0	10	0	10	0	
Abductors (left)	9.11	0.6	9.56	1.1	8.89	1.36	0.108
Abductors (right)	8.89	0.93	9.33	1	9.33	1.12	0.186
Hip Extensors (left)	8.33	2	8.67	2.18	8.22	2.33	0.368
Hip Extensors (right)	8.44	1.88	8.89	2.09	9.11	1.36	0.276
Knee Extensors (left)	10	0	10	0	9.89	0.33	0.368
Knee Extensors (left)	9.67	0.71	10	0	10	0	0.135
<b>Activity measures</b>							
1 Minute Walk Test	77.21	21.13	81.99	23.14	81.01	19.84	0.49
Timed Up and Go	9.67	4.18	8.65	3.24	8.33	2.96	0.142
<b>Participation measure</b>							
LIFE-H Total	8.73	1.15			8.81	0.72	0.594
LIFE-H Satisfaction	4.45	0.32			4.5	0.28	0.176

LIFE-H, Assessment of life habits questionnaire (LIFE-H 3.1 - General Short Form).

Results from the cycle ergometer test was not analysed. One participant was prescribed medication affecting heart rate between post and follow-up testing. Although medical clearance allowed exercise testing, the medication affected the test's validity and the results were disregarded. For other

participants, inability to grip handles (n=1), inability to pedal at a steady rate (n=2) and missing data (n=1) resulted in insufficient valid data to justify conducting statistical tests

Table 4 summarizes the qualitative reports by the participants and their parents in the interviews. These comments corresponded to the three levels of the ICF and are described in detail, as such, under the following three sections: body functions and structures, activity, and participation. When asked about difficulties during the program six participants stated they found nothing difficult. Three said they found one or more pieces of equipment difficult to use, grip or get on and off. Participant 8 suggested a higher staff: participant ratio may encourage further motivation. No further suggestions for future changes were made.

**Table 4:** Incidence of reports of improvements by participants and their parents and guardians in interviews at post and follow-up testing.

<b>Body Structures and Function</b>	<b>N</b>	<b>Activity</b>	<b>N</b>	<b>Participation</b>	<b>N</b>
<b>Physical Function</b>					
Feels stronger	6	Improved gait	4	Increased participation in physical activity	6
Improved Endurance/ Stamina/ Fitness	5	Standing Taller/ for longer	3	Increased participation in social/ leisure activities	3
Increase in muscle size	4	Improved ability to operate equipment	3	Enjoyed Program	7
Improved Balance/ Decreased fear of falling	2			Enjoyed social interaction	3
Improved co-ordination	2				
Increased Flexibility	1				
Weight loss	1				
<b>Psychological function</b>					
Improved self confidence	4				
Improved motivation/ energy	4				
Improved sleeping patterns	2				
Improved eating patterns	1				
Improved communication/ Opening up or talking more	1				
Decreased incidence of illness/ Improved sense of well-being	1				

**Body Functions and Structures**

Perceived improvements in strength, muscle size, stamina, endurance, fitness and balance were reported. Participant 4 stated “I’m not scared anymore...of people bowling me over”. Weight loss, increased flexibility in the legs and decreased incidence of illness were reported by one participant. Participant 1 reported “I’ve been sick less, I usually get a lot of colds...it got me healthier”.

Improvements in Psychological Function were also reported, particularly improved self-confidence and motivation or energy. Participant 3 stated “I have more energy, and more will to do things. I actually can get up in the morning and get up and go instead of taking half an hour to sort of work myself into getting up and going out”. Sleeping and eating patterns also altered. Participant 4’s mother said “She was a chocoholic...but since she’s been doing the gym she doesn’t eat as much chocolate anymore and a lot of the junk food she won’t eat...she just doesn’t crave it anymore”.

**Activity**

Several participants commented on improved gait and an ability to stand taller and for longer. When asked about changes in herself since commencing training, participant 3 stated “I’d hate to see myself walk in a window and my head bob up and down and I’d just cringe but now I walk past the car and I don’t go up and down as much any more and that’s because of doing exercise and because of coming to the gym”. Several participants learnt to operate the equipment in the gym. The mother of participant 4 commented, “We started off with pushing both legs down [on the stationary bike]...then it progressed to one, then finally she could get on there and do it herself”

**Participation**

Most participants said that they had increased their physical activity as a result of the program. Participant 8 reported that she was “more motivated to exercise on a more regular basis to maintain fitness levels”.

Improved self-confidence sometimes led to increased participation in leisure activities. The father of participant 2 said, “He has more confidence. Like yesterday, when we were on the boat on the river, the kids would climb up to the top and dive into the river. And he wouldn’t have had the confidence to do that before”. Participant 3 stated, “I think it really taught me to accept things and that I could do things and that I wasn’t completely written off and I could do exercise and it wasn’t a waste of time and that it did help and it did make me look better where before I was like, ‘well what’s the point? I’m not going to get any better anyway so I may as well do nothing.’ But everybody says to me now, ‘wow look you can stand up for longer and we can take you to a night club and you don’t fall over and its not embarrassing’ and I’m not embarrassed anymore because I know that I can do things and I don’t care”. Furthermore participant 4’s mother commented on her daughter’s improved social interaction and more open communication following participation in the program.

Two participants said they were more able to participate in community outings. Participant 4’s mother reported, “I had been thinking of things for [participant 4] to do, a gym program and that, but I just

didn't know how to go about it... so that's given us another thing for [participant 4] to do as well, other than just going to work and coming home". Participant 3 commented on her stair-climbing after the training program, "I would be dependent on a rail or to hold someone's hand... and now I have a bit of confidence and physical ability to do it myself... when I go out at night times and things, most of the places have stairs which I tried to avoid and now I don't have to".

### **Contextual Factors**

The group context facilitated enjoyment and social interaction. Most participants spontaneously commented on the value of these contextual factors. The father of participant 2 reported, "He never once needed pushing to come along. He was always keen to come along to the sessions". Participant 3 commented, "It's not about my disability; it was about my ability and how much I could do and I was really surprised I enjoyed it... it was so fun and everyone was competing with each other".

At post-test, seven out of eight participants reported they would like to continue a regular training program and four specified a community gym (see Table 4). At follow-up, only one of these four, as well as one other participant (not interviewed at post-test), was training at a community or school-based gym. At follow-up, four participants were still intending to exercise in a community or school gym, though they hadn't started yet. Reasons given for not exercising at a community gym included practical considerations (such as parents or participants not having sufficient time, participant study commitments and cost) and concerns regarding the number of people in public gyms and about using equipment independently. Participant 8 said, "A gym I didn't know and having to do the equipment and everything myself, I'd be a little too overwhelmed to do that...I've been to the gym with my school and things but there's been someone there to help I don't really want to go to the gym by myself".

Participant 3, who had begun training at a community gym, described the experience negatively, saying she no longer enjoyed exercising because: there was no motivation; it was difficult to keep up with her friends; there were long waits for machinery; it was difficult to do the circuit with others in the way; and there was no structure and no goals. She stated, "having people around the same age as you with the same abilities - its really boosting because you are not watching people that are always going to be better than you or stronger than you, and you have a personal best and you end up wanting to beat yourself because you feel good about what your doing. And the motivation that was provided for us, that helped a lot... At our local gym... they're all a lot older and they're not very social and they're there to lose weight and that's about it and they don't want to talk and they don't want to socialise... They don't care that you can get on and off a bike and it doesn't matter. But here, the little things mattered, which made everything so much better".

### **DISCUSSION**

Statistically significant changes in true popliteal angle suggest that circuit training can lead to measurable changes in *impairment* in adolescents and young adults with spastic diplegia. At each training session participants stretched major muscle groups, including hamstrings. In addition, many participants reported increases in activity and participation with training, and as such altered biomechanics or

increased physical activity may also account for this finding. Other measured changes in limb and lower limb flexibility, however, did not reach significance. Another study found no significant difference in hamstring flexibility between measures taken before and after strength training for adolescents with CP.<sup>17</sup> Self-reported increases in strength and fitness as well as improved balance and co-ordination, increased flexibility and muscle bulk and weight loss in the present study are consistent with qualitative evidence for improvements in strength, flexibility, posture and balance following strength training.<sup>11, 12</sup>

Self-reported improvements in self-confidence, motivation and energy were key psychological benefits. Strength training literature has also recently reported qualitative evidence for the improvement of psychological function in CP populations, including increased energy, sense of well-being and self-confidence.<sup>11, 12</sup> The other improvements in psychological function, including communication and sleeping and eating patterns have not previously been reported in strength training literature.

In this study, there were no significant changes in strength measurements. A systematic review investigating the measurement and treatment of weakness in CP comments on the difficulty of measuring strength in CP populations owing to altered motor control and excessive co-contraction, characteristics of CP which may impair voluntary muscular contraction.<sup>7</sup> Furthermore, practical restrictions encountered in this study, and described in the literature, such as difficulty adopting testing positions and the presence of muscular synergies, make it difficult to detect strength changes<sup>7</sup>. Furthermore, it may be challenging for some participants to comprehend and comply with repeated requests for maximal contraction, and consequently the validity of strength testing may be compromised<sup>7</sup>.

The sub maximal upper limb ergometer test, although selected for its apparent suitability for the diplegic population, also presented difficulties which affected its validity as a fitness test. Pre-testing was generally successful. However, at post-test and follow-up testing, when higher resistance was needed to elicit target heart rates, it became difficult to co-ordinate a steady rapid enough cycling rate against high resistance to raise heart rates to the target. Excessive trunk movement caused the polar heart rate monitors to slip, even when fully tightened, (producing erratic heart rate readings), and the resistance on the ergometer to slip down. In future research, consideration should be given to the pragmatics of fitness testing in this population.

Objective changes were not found in the *activity* or *participation* levels of participants. This may be because a ten weeks of circuit-training program was too little, or it may be that strategies need to be incorporated into the program to encourage participants to generalize their participation to other settings. However qualitative evidence was found for self-reported changes at all levels of the ICF. The small sample was a study limitation and this study may have lacked the power to detect a change in objective measures. Recruitment efforts were extensive but the response rate was low, and the withdrawal rate, before the commencement of the study, high. Research shows recruitment is particularly difficult with populations with disabilities.<sup>36</sup> Consequently, a control group could not be formed in this study. A review on strength training for people with CP suggested that small numbers and a wide range of impairments make creating studies of a rigorous experimental design difficult in this population.<sup>37</sup>

The participants in this study showed a broad range of physical functioning, evidenced by the large standard deviations for most measures (see Table 3). All participants reported benefits of training. However, some of the measurement tools, including MMT and the TUG test, were not challenging for the participants with higher physical function, and ceiling effects were observed. For example, many participants scored a grade five in MMT at pre-test and thus could score no higher following training.

This study found qualitative evidence for the improvement of *activity* with circuit training, thus contributing to the modest amount of literature reporting activity improvements following strength training.<sup>5 11, 12 13 14 15</sup> Improved standing and ambulatory ability, the key activity improvements found in this study, are central therapy goals for people with CP. These goals are particularly significant during adolescence and young adulthood when individuals are prone to a decline in ambulatory ability.<sup>4</sup>

The increased *participation* in physical activity reported by most participants in this study adds to the anecdotal reports of increased participation in community-based exercise,<sup>17, 38</sup> and therapy and school activities<sup>13</sup> following strength training. One participant in our study reported that increased self-confidence (an improvement in psychological function) following circuit training had led to participation in community-based exercise. Three participants also attributed increased participation in leisure activities and social communication to an improvement in self-confidence. Further participants identified a link between improved *physical* function and participation, two of whom reported that participation in the program created the opportunity for increased participation in community based activities. These findings are consistent with qualitative evidence for improved physical functions and resulting increased participation in social and leisure activities following home-based strength training in adolescents with CP.<sup>11</sup>

Enjoyment of the program, and particularly the group interaction, was reported by a number of participants in this study. Enjoyment, primarily from social interaction, has been reported as a key benefit of a community-based strength training program for adults with CP,<sup>12</sup> and was probably responsible for the high retention rate in this study. Research shows retention, like recruitment, is particularly difficult in research involving populations with disabilities,<sup>36</sup> and another recent strength training study retained only 50% of adolescents with CP, possibly because they exercised individually and not in a group.<sup>14</sup> Enjoyment has been associated with adherence to exercise in a CP population.<sup>11-13, 15, 17</sup> In a study involving a community-based strengthening program for adolescents with CP the continuation of exercise following the program's completion was attributed to social connections made during the study.<sup>17</sup> As people with CP risk social isolation during adolescence and young adulthood,<sup>41</sup> the opportunities for enjoyment and social interaction offered by group based training programs are of great importance.

### **Implications For Practice**

Authors of a RCT conducted in 2003 suggested the need for more clinically feasible strength training programs involving less expensive and more easily accessible testing and training equipment.<sup>10</sup> While the training equipment used in this program is expensive to buy, it is readily accessible to the general public in community gymnasiums. The testing equipment used was clinically based and while few objective changes were seen in this study, further research is needed to determine if objective changes

may be seen in controlled studies with larger study samples. A student exercise physiologist ran each program (4-5 participants per cohort) and a physiotherapist was present at all training sessions for safety. This staff-to-participant ratio allowed safe and efficient transfer between stations. In an attempt to standardize the program, we used repetitions and sets to increase the work volume throughout most of the program. This probably resulted in participants exercising at a lower than desirable intensity. Increasing the resistance earlier and more frequently may have led to greater strength changes. To ensure participants always work within their training zones, we suggest reviewing resistance after two weeks and continuing to review throughout for future circuit-training programs.

This study aimed to investigate the feasibility of running a program to teach adolescents and young adults how to use equipment they could access independently in the community. It has been suggested that exercise programs run within the community environment promotes a social rather than medical view of exercise and can lead to improved confidence, and a more positive attitude towards disability, in a CP population.<sup>17</sup> In this study, all participants increased their mastery of equipment use over the program, and by post-test all had learnt to use the gym equipment with no or minimal assistance. However this study found that the transition to community gyms did not occur automatically. Although most participants increased their physical activity following the program, only two began exercising at community and school gyms, in spite of reports of enjoyment and the intentions by many to exercise at a community gym. A recent survey of adults with CP reported that although most were participating in physical activity, only a small percentage were involved in organized sport or had trained at a community gym.<sup>42</sup> This study found more commonly adults completed home exercises from a physiotherapist or completed individual leisure activities.<sup>42</sup> In our study, reasons given for not exercising at a community or school gym were diverse, and further research into the barriers to community-based physical activity for people with CP will be necessary before strategies can be developed to ease the transition to community-based exercise.

During the course of the interviews, it was clear that many participants and their parents were unsure of the benefits of resistance versus fitness exercise and were surprised by how quickly reported gains were lost when exercise was ceased. Others seemed unaware of available community resources. Incorporating an educational component into the program, including information on the long-term benefits of exercise, guidelines for maintaining strength and fitness, and information on price, local recourses and transport options, could address this confusion and help aide transition to community facilities. An initial appointment at a community gym, with a health professional to set exercise parameters may be helpful. For more independent participants, a list of training equipment and appropriate parameter settings, given at the end of the program, may be more appropriate. Given the importance of social support reported in this and other research<sup>12, 37</sup>, thought must be given to maintaining this in the community. Options such as organising employed leisure buddies, or arranging a buddy system between program participants may be beneficial.

In conclusion, this research demonstrated that group-based circuit training is a viable strategy, with a high retention rate, for adolescents and young adults with cerebral palsy. The combination of assessment tools used in this study was unique in its attempt to objectively measure change at all levels of the ICF, and measurable changes were seen in hamstring flexibility. All participants spontaneously reported benefits of training and all learnt to use gym equipment with little or no assistance. Self-reported benefits of training including improvements in psychological function, as well as increased participation in leisure activities and community-based physical activity, are areas of interest in current CP literature. The program proved a safe and effective step towards forming a bridge between segregated therapy and community-based physical activity.

## REFERENCES

1. Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of cerebral palsy April 2006. *Developmental Medicine & Child Neurology*. February 2007;109:8-14.
2. Murphy K, Molnar G, Lankasky K. Medical and functional status of adults with cerebral palsy. *Developmental Medicine & Child Neurology*. 1995;37:1075-1084.
3. Sandstrom K, Alinder J, Oberg B. Descriptions of functioning and health and relations to a gross motor classification in adults with cerebral palsy. *Disability & Rehabilitation*. September 2 2004;26(17):1023-1031.
4. Day M, Wu Y, Strauss D, Shavelle R, Reynolds R. Change in ambulatory ability of adolescents and young adults with cerebral palsy. *Developmental Medicine & Child Neurology*. 2007;49:647-653.
5. Andersson C, Grooten W, Hellsten M, Kaping K, Mattsson E. Adults with cerebral palsy: walking ability after progressive strength training. *Developmental Medicine & Child Neurology*. 2003;45:220-228.
6. Damiano DL, Vaughan C, Abel MF. Muscle response to heavy resistance exercise in children with spastic cerebral palsy. *Developmental Medicine & Child Neurology*. 1995;37:731-739.
7. Damiano D, Dodd K, Taylor N. Should we be testing and training muscle strength in cerebral palsy? *Developmental Medicine & Child Neurology*. 2002;44:68-72.
8. Dodd K, Taylor N, Damiano D. A Systematic Review of the Effectiveness of Strength-Training Programs for People With Cerebral Palsy. *Archives of Physical Medicine and Rehabilitation*. 2002;83(August):1157-1164.
9. WHO. International Classification of Functioning, Disability and Health. <http://www.who.int/classifications/icf/site/index.cfm>. Accessed 15th of September, 2007.
10. Dodd K, Taylor N, Graham H. A randomized clinical trial of strength training in young people with cerebral palsy. *Developmental Medicine & Child Neurology*. 2003;45:652- 657.
11. McBurney H, Taylor N, Dodd K, Graham H. A qualitative analysis of the benefits of strength training for young people with cerebral palsy. *Developmental Medicine & Child Neurology*. 2003;45:658-663.
12. Allen J, Dodd K, Taylor N, McBurney H, Larkin H. Strength training can be enjoyable and beneficial for adults with cerebral palsy. *Disability and Rehabilitation*. 2004;26(19):1121- 1127.
13. Unger M, Faure M, Frieg A. Strength training in adolescent learners with cerebral palsy: a randomized controlled trial. *Clinical Rehabilitation*. 2006;20:469-477.
14. Eagleton M, Iams A, McDowell J, Morrison R, Evans C. The Effects of Strength Training on Gait in Adolescents with Cerebral Palsy. *Pediatric Physical Therapy*. 2004;16:22-30.
15. Taylor N, Dodd K, Larkin H. Adults with cerebral palsy benefit from participating in a strength training programme at a community gymnasium. *Disability and Rehabilitation*. 2004;26(19):1128-1134.

16. Taylor N, Dodd K, Damiano D. Progressive Resistance Exercise in Physical Therapy: A Summary of Systematic Reviews. *Physical Therapy*. November 2005;85(11):1208-1223.
17. Darrah J, Wessel J, Nearingburg P, O'Conner M. Evaluation of a community fitness program for adolescents with cerebral palsy. *Pediatric Physical Therapy*. 1999;11:18-23.
18. Fernandez J, Pitetti K, Betzen M. Physiological capacities of individuals with cerebral palsy. *Human Factors*. 1990;4:457-466.
19. Fowler E, Kolobe T, Damiano D, et al. Promotion of Physical Fitness and Prevention of Secondary Conditions for Children With Cerebral Palsy: Section on Pediatrics Research Summit Proceedings. *Physical Therapy*. November 2007;87(11):1495-1510.
20. Pitetti K, Fernandez J, Lanciault M. Feasibility of an exercise program for adults with cerebral palsy: a pilot study. *Adapted physical activity quarterly (Champaign, Ill.)*. 1991;8(4):333-341.
21. Van den Berg-Emons R, van Baak M, Speth L, Saris W. Physical Training of school children with spastic cerebral palsy: effects on daily activity, fat mass and fitness. *International Journal of Rehabilitation Research*. 1998;21:179-194.
22. Shinohara T, Suzuki N, Oba M, Kawasumi M, Kimizuka M, Mita K. Effects of Exercise at the AT Point for Children with Cerebral Palsy. *Hospital for Joint Diseases*. 2002-2003;61(1 and 2):63-66.
23. Schlough K, Nawoczinski D, Case L, Nolan K, Wigglesworth J. The Effects of Aerobic Exercise on Endurance, Strength, Function and Self-Perception in Adolescents with Spastic Cerebral Palsy: A Report of Three Case Studies. *Pediatric Physical Therapy*. 2005;17(4):234-250.
24. Rimmer J. Physical fitness levels of persons with cerebral palsy. *Developmental Medicine & Child Neurology*. 2001;43:208-212.
25. McArdle W, Katch F, Katch V. *Exercise Physiology Energy, Nutrition and Human Performance*. sixth ed. Baltimore; 2007.
26. Fougereyrollas P, Noreau L, Beaulieu M, et al. *Assessment of Life Habits (LIFE-H 3.1): General Short Form*. Lac-Saint-Charles, Québec: INDCP; 2002.
27. Fletcher G, Balady G, Amsterdam E, et al. Exercise Standards for Testing and Training A Statement for Healthcare Professionals From the American Heart Association. *Circulation*. 2001(October 2):1694- 1740.
28. Gibson N, Laird K, Mori R, Shillington T. *Paediatric Biomechanical Assessment of the Lower Limb: Significance to the Interpretation of Gait*. Perth: Princess Margaret Hospital Physiotherapy Department,; 2002.
29. Clarkson H. *Musculoskeletal assessment Joint Range of Motion and Manual Muscle Strength*. Baltimore, Maryland: Lippincott Williams and Wilkins; 2000.
30. Mutlu A, Livanelioglu A, Gunel M. Reliability of goniometric measurements in children with spastic cerebral palsy. *Medical Science Monitor*. July 2007;13(7).

31. Maruishi M, Mano Y, Sasaki T, Shinmyo N, Sato H, Ogawa T. Cerebral Palsy in Adults: Independent Effects of Muscle Strength and Muscle Tone. *Archives of Physical Medicine & Rehabilitation*. 2001;82:637-641.
32. McDowell B, Kerr C, Parkes J, Cosgrove A. Validity of a 1 minute walk test for children with cerebral palsy. *Developmental Medicine & Child Neurology*. 2005;47:744-748.
33. Kerr C, McDowell B, Cosgrove A. Oxygen cost versus a 1-minute walk test in a population of children with bilateral spastic cerebral palsy. *Journal of Pediatric Orthopedics*. April-May 2007;27(3):283-287.
34. Noreau L, Desrosiers J, Robichaud L, Fougere P, Rochette A, Viscogliosi C. Measuring social participation: reliability of the LIFE-H in older adults with disabilities. *Disability and Rehabilitation*. 2004;26(6):346- 352.
35. Morris C, Kurinczuk J, Fitzpatrick R. Child or family assessed measures of activity performance and participation for children with cerebral palsy: a structured review. *Child: Care, Health & Development*. 2005;31(4):397- 407.
36. Blanton S, Morris D, Prettyman M, et al. Lessons Learned in Participant Recruitment and Retention: The EXCITE Trial. *Physical Therapy*. November 2006;86(11):1520-1533.
37. Darrah J, Fan J, Chen L, Nunweiler J, Watkins B. Review of the Effects of Progressive Resisted Muscle Strengthening in Children with Cerebral Palsy: A Clinical Consensus Exercise. *Pediatric Physical Therapy*. 1997;9(1):12-17.
38. Lockwood R. *Effects of isokinetic strength training on strength and motor skill in athletes with cerebral palsy*. Perth (Aust): Australian Sports Commission; 1993.
39. van der Dussen L, Nieuwstraten W, Roebroek M, Stam H. Functional level of young adults with cerebral palsy. *Clinical Rehabilitation*. 2001;15:84-91.
40. Donkervoort M, Roebroek M, Wiegerink D, Van Der Heijden-Maessen H, Stam H, Netherlands TTRGSW. Determinants of functioning of adolescents and young adults with cerebral palsy. *Disability & Rehabilitation*. March 2007;29(6):453-463.
41. Rosenbaum P, Livingston M, Palisano R, Galuppi B, Russell D. Quality of life and health-related quality of life of adolescents with cerebral palsy. *Developmental Medicine & Child Neurology*. 2007;49:516-521.
42. Andersson C, Mattsson E. Adults with cerebral palsy: a survey describing problems, needs, and resources, with special emphasis on locomotion. *Developmental Medicine & Child Neurology*. 2001;43:76-82.